DIGITAL WATERMARKING OF SATELLITE IMAGERY USING THE ALGORITHM BASED ON A LOOK-UP TABLE METHOD

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ABSTRACT ... Digital image watermarking is a technology used in copyrighting of digital images by embedding unremovable informations. In this paper, a pixel-domain look-up-table-based watermarking algorithm is presented. With this methodology, the watermark was embedded in the host image, but we did not observe any distortion at certain specific region of interest. This means the proposed method is preferred in case of satellite images. Then, the image manipulation tool which is called 'StirMark' will be used to perform many kinds of attacks such as rotation, scaling, filtering and compression on the watermarked image. Finally, the effectiveness of a watermarking technique in terms of 'robustness' and 'data integrity' criteria will be measured by calculating PSNR of watermark and watermarked image.

KEY WORDS: Watermarking, Satellite Imagery, StirMark, Look-up Table

1. INTRODUCTION

With the advancement in memory unit and internet, satellite images can be easily purchased and distributed on the Web. Hence, there need to be some way to protect the copyrights of digital images. (Cox, Katzenbeisser) Many techniques for copyright protection and proof of rightful ownership of satellite images have been developed. The pros and cons of each technique is known for appropriate application to many kinds of digital images.

In case of 2D digital image, watermarking is the most popular way of protecting copyright. A small and meaningful mark is embedded in the image and used as a signature of the image.

In this paper, the spatial-domain image watermarking technique using Look-up Table method is used. This technique has an embedding process that is performed on a image pixel by pixel. It allows users to determine the Region of Interest in which the pixel values are not modified during embedding process. The Region of Interest (RoI) means the range of pixel values which are of interest to the user. Therefore, this technique would be useful for satellite images used for image interpretation or classification.

2. ALGORITHM BASED ON A LOOK-UP TABLE METHOD

2.1 Generating Look-up Table and Watermark

The Look-up Table (LuT) is a random sequence consists of 0's and 1's. It is generated once by the user when he/she embeds a watermark in an image. Its length equals the number of all possible pixel values. In case of 8bit panchromatic image, it becomes 256.

A watermark for this algorithm needs be a simple binary image of a trademark, a character, a word, etc. Its size is relatively small to the host image.

2.2 Determination of Region of Interest

In many cases involving satellite images, the user is specifically interested in a particular region only. Pixel values in this region can be fixed during a watermarking process. This region, which is called as the Region of Interest (RoI), is specific to the user's needs and requirements. Its range of pixel values is specified by properties of the corresponding area in the image. The pixel ranges for different areas are stored in a database by the owner. (Chauhan)

2.3 Embedding Watermark via Look-up Table

Not all pixels in the host image are modified but some pixels are selected with a constant period in spatial domain. If the value of a selected pixel lies in the RoI that is determined above, it is excluded from the set of selected pixels and, consequently, its value is fixed during the embedding process. The value of a selected pixel is changed by the following rule.

About the i-th pixel among selected pixels from the host image, let the pixel value 'v'. Then, if the v-th element in the LuT is equal to the value of the i-th pixel in the watermark, its pixel value is not modified. Otherwise, the pixel value is slightly modified so that the $(v+d)$-th element in the LuT is equal to the value of the i-th pixel in the watermark, where d is variation in original pixel value. The smallest value is taken to be d to maximize the data integrity of watermarked image. This embedding algorithm can be summarized as Figure 1.

Let the pixel selecting period N. The most appropriate value of N is determined by the following rule.

$$N = \min_{[x]}\left\{ x \in \mathbb{N} \;\middle|\; \begin{array}{l} x \text{ is a prime} > \frac{P}{W} \\ \text{and } P \neq mx \text{ for } m \in \mathbb{N} \end{array} \right\} \quad (1)$$

where P and W is the size of the host image and the watermark, respectively. This rule enables the selecting process to be performed over the whole area of the host image. The value should be a prime number to avoid selecting the same pixel in the host image again.

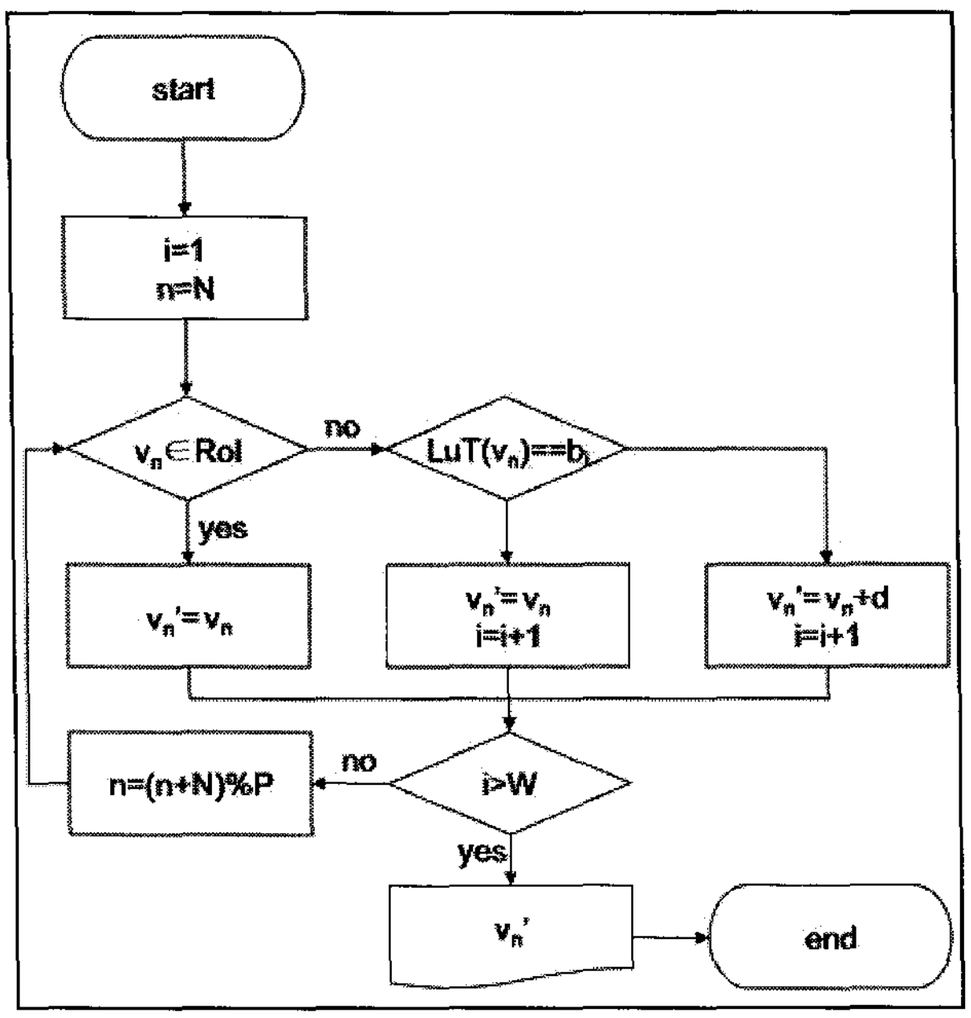

Figure 1 Flow Chart of Embedding Process

The important parameters in this watermarking algorithm are 'N' and the LuT which play decisive roles. They are the 'keys' to embedding and extracting algorithm. The copyrighter of an image generates an appropriate N and LuT according to the rules above, and ensures that nobody without a copyright can get the keys. Therefore, the copyrighter is the only person who can extract the watermark from the image. No one can extracts watermark unless they have copyright because randomized LuT cannot be inferred logically.

2.4 Watermark Extraction

The watermark can be extracted easily if the 'key' which had been used to embed watermark is preserved. About the i-th pixel among selected pixels from the watermarked image, let the pixel value v'. Then, the value of the i-th pixel in watermark is equal to the v'-th pixel in LuT. Finally, the watermark is reproduced completely. This extracting algorithm can be summarized as Figure 2.

Pixel values of image had been modified by embedding process so that LuT-transformed values equal the pixel values in the watermark. Thus watermarked image can directly reproduce the watermark.

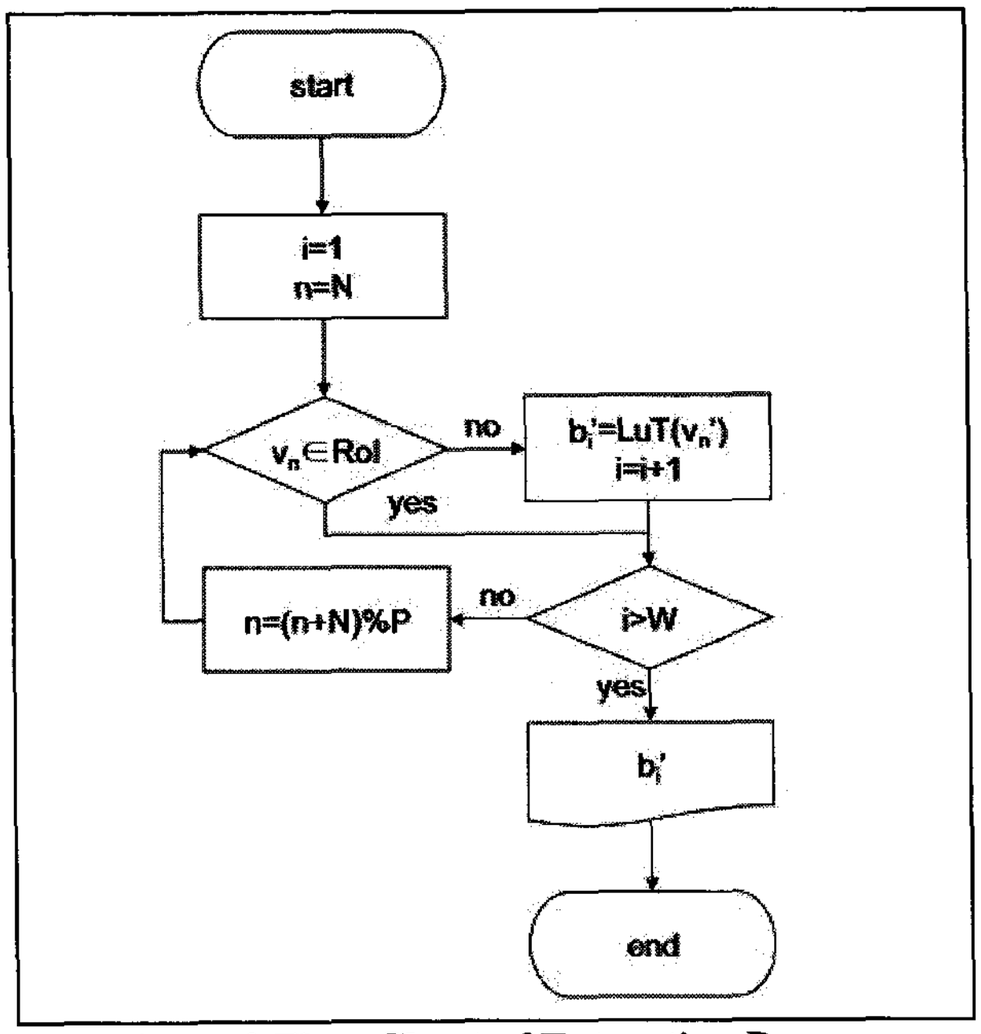

Figure 2 Flow Chart of Extracting Process

3. EXPERIMENTAL RESULT

A JPEG compressed 601×501 Quickbird image of Daejeon area was used for this experiment. (Please refer to Figure 3.) It is a 8-bit panchromatic image so its pixel values are in the range of 0~255. The RoI was set as 158~172 that represents the soil region, and the watermark of 100×100 size was used. (Please refer to Figure 4.)

This watermark is embedded onto the host image. The corresponding watermarked image and the watermarked region is shown in Figure 5 and Figure 6, respectively.

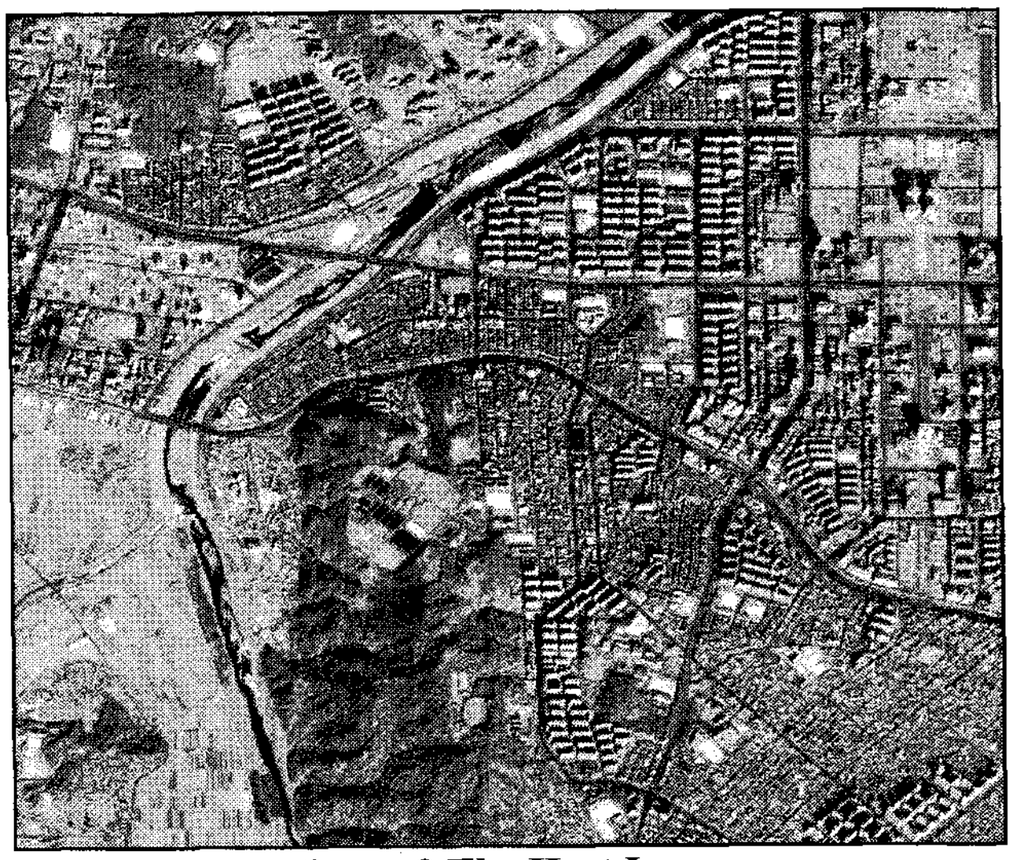

Figure 3 The Host Image

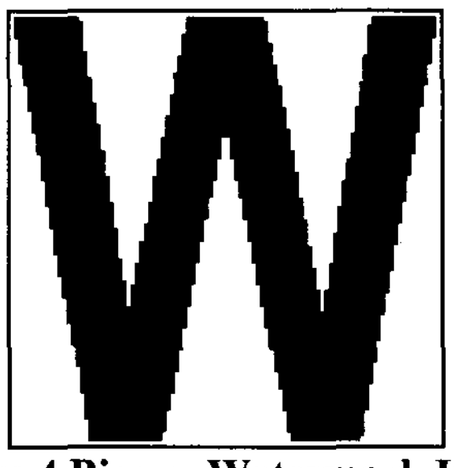

Figure 4 Binary Watermark Image

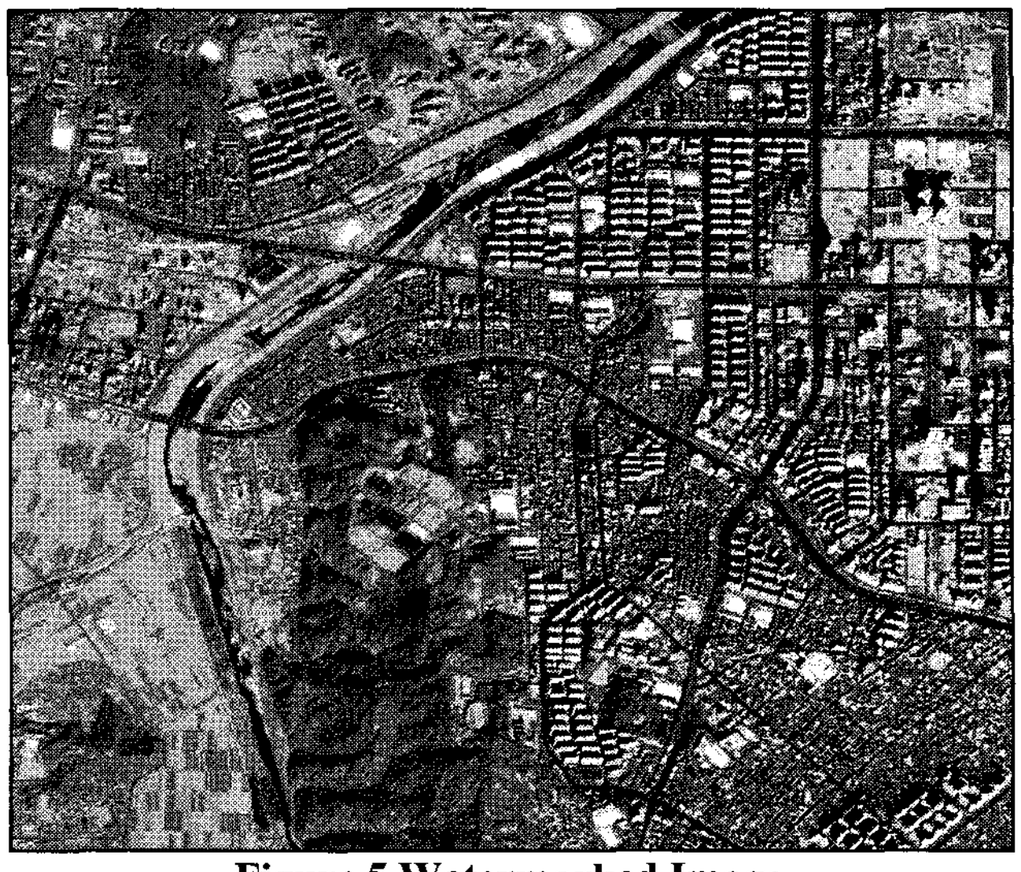

Figure 5 Watermarked Image

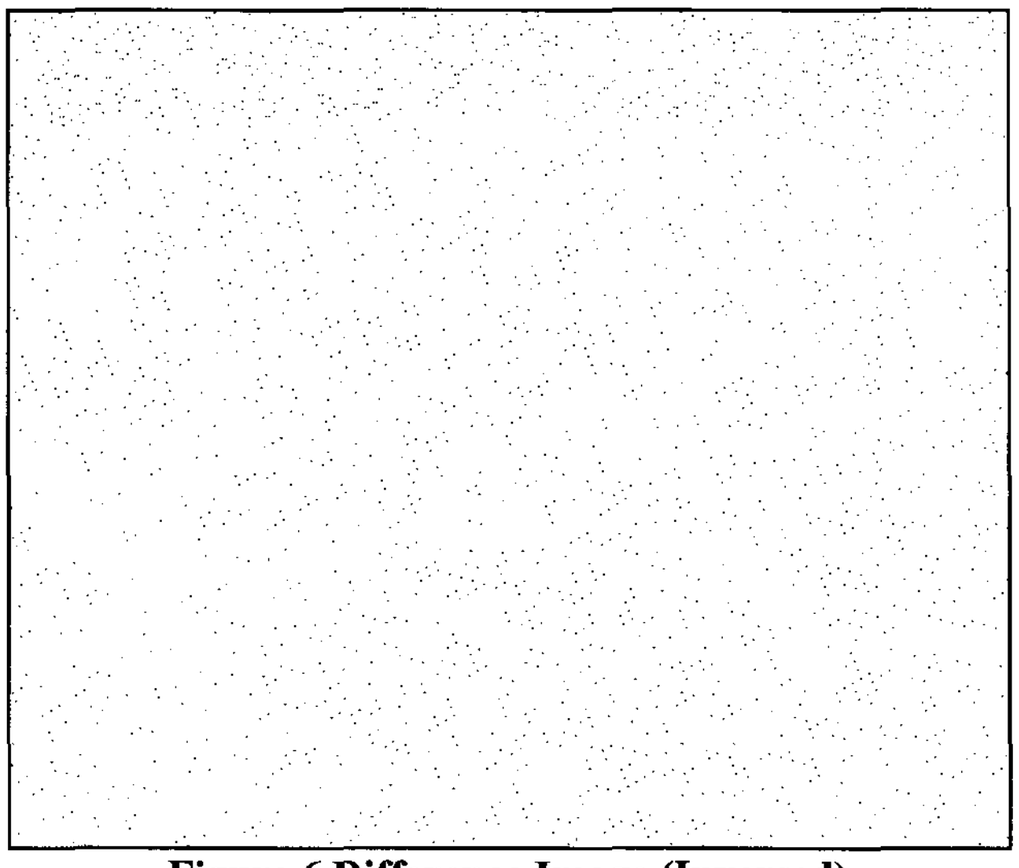

Figure 6 Difference Image (Inversed)

4. CONCLUSION AND FUTURE WORKS

To protect the copyright of a digital image, many watermarking techniques have been developed and is now being used. The spatial-domain image watermarking technique using the algorithm based on a Look-up Table method was introduced and practically applied to a panchromatic satellite image. This algorithm is effective especially for satellite imagery as the Region of Interest can be determined depending on the user's requirements. We embedded the watermark in the host satellite image, and then extracted it using the key generated by embedding process. The watermark was reproduced completely and pixels in the RoI were not changed in value.

There are many watermarking algorithms for digital image. The effectiveness of these algorithms are measured by degrees of 'robustness' and 'integrity'. (Ho) Robustness represents the quality of watermark remained after some geometric or radiometric attack on a watermarked image and integrity is an index of invariableness between host and watermarked image.

To get robustness of watermarking algorithm, the watermark should be embedded 'deeply'. It leads to more large difference between host and watermarked image. Thus the integrity of the algorithm is deteriorated. This is a problem with 'inperceptibility' which is one of the most important features of an effective watermarking technique. In addition, the results of image interpretation or classification produce more error as each pixel values are changed.

Therefore, the 'effectiveness' of a watermarking algorithm means that the robustness and the integrity have been adjusted to user's requests in many cases. In case of satellite images, a watermarking algorithm is not required to be robust as any attack on the image would result in the deterioration of the commercial value of the image. (Chauhan) Instead, integrity is treated as an significant measure of an algorithm.

There is an open-sourced benchmarking software named 'StirMark'. StirMark calculates PSNRs of watermark and watermarked image to measure the robustness and the integrity of a watermarking algorithm. It is planned that some PSNR calculating tools such as StirMark can be used to measure the effectiveness with quantitative analysis. (Ho)

Another area that we are currently investigating is the effect of many ways to set the RoI. The RoI which is determined by the range of spatial coordinates is also part of our research scope.

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